

# Limnological Evaluations

Using Satellite Data to Determine Lake and  
Reservoir Water Quality

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- Overview of past/ present monitoring techniques
- Principles of satellite data acquisition
- Making remotely-sensed data useful
- Advantages and disadvantages



# History of Lake Assessment in Idaho

- Clean Lakes Studies
- Single lake water quality data collections
- Statewide assessment process (Lake BURP)
  - Stream processes based (WBAG I)
  - Focused on biological communities
  - Used individual water quality parameters
  - Statewide Assessment Process failed due to lack of appropriate data, funding, and personnel work-group turnover



# Ambient Lake-Reservoir Assessment Process

- Acquire relevant data
  - Secchi Dish depth (SD)
  - Temperature
  - Bacteria
  - Chlorophyll-a concentration
  - Total Nitrogen (TN)
  - Total Phosphorous (TP)
  - Dissolved Oxygen (DO)



- Individual parameters and Indexes



Carlson (1977) devised a method of quantifying lake health (trophic state) by integrating various water quality parameters into a simple index

- Secchi Depth (SD): a measure of water clarity
- Chlorophyll-a (Chl): a measure of plant productivity
- Total Phosphorous (TP)
- Total Nitrogen (TN)

$$\text{TSI(AV)} = [\text{TSI(SD)} + \text{TSI(Chl)} + \text{TSI(TP)} + \text{TSI(TN)}] / 4$$

$\leq 40$  Oligotrophic

40 to 50 Mesotrophic

50 to 70 Eutrophic

$> 70$  Hypereutrophic

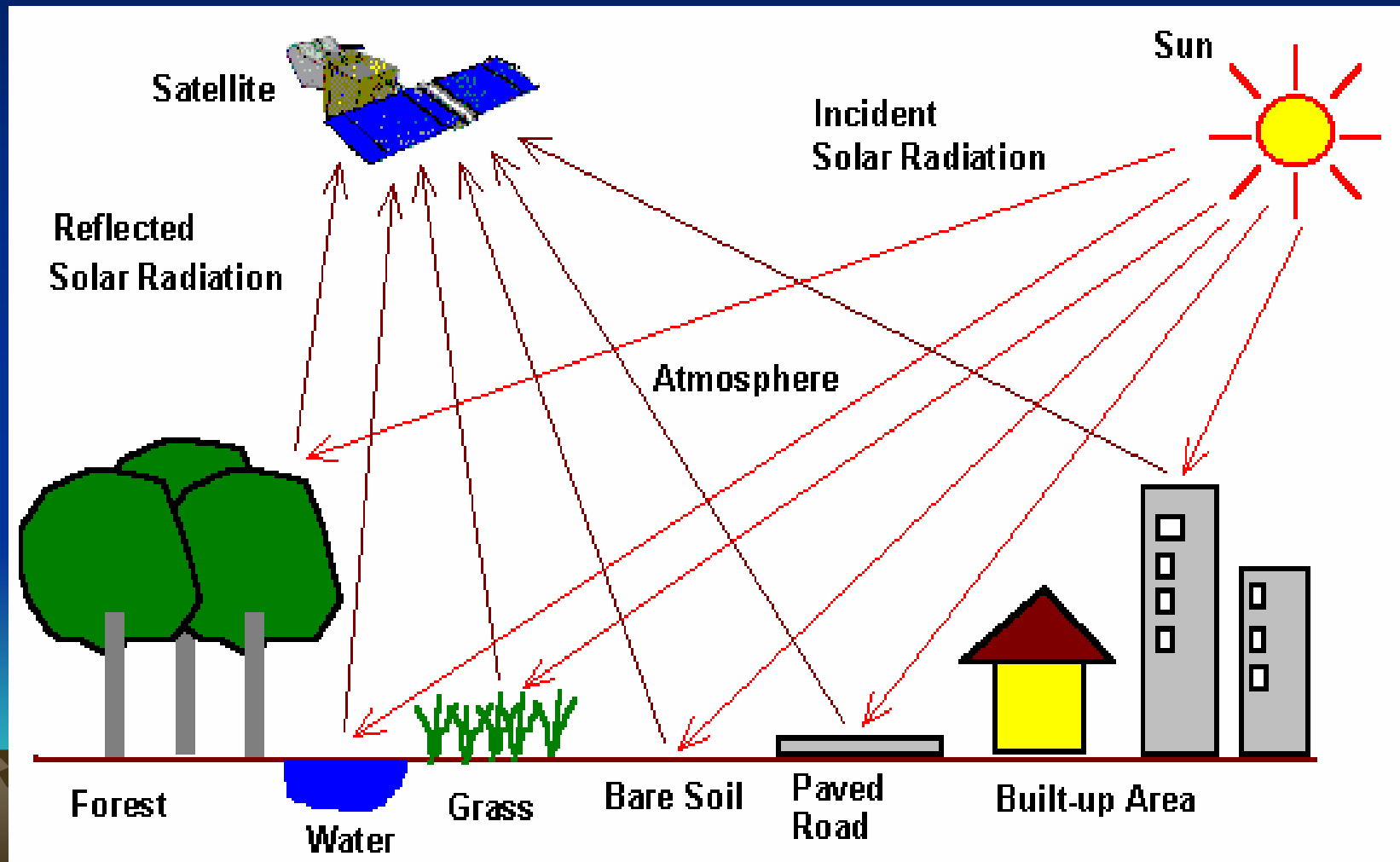


# The Landsat Program

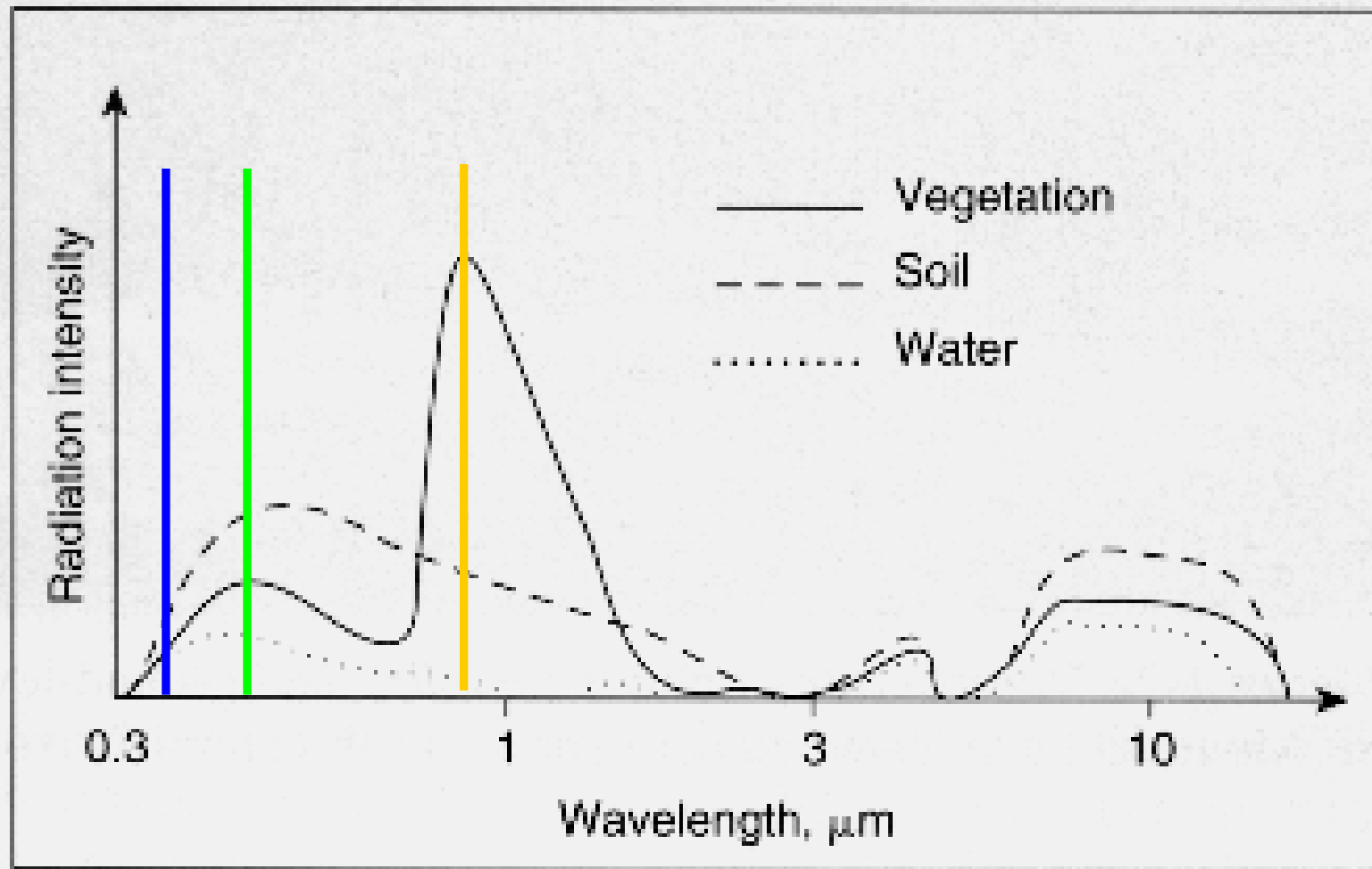
- Availability of Landsat data
  - 1972-8 Landsat 1,2, and 3
  - 1980's Landsat 4 TM and Landsat 5 TM
  - 1999 Landsat 7 ETM+
- Why has the use of Landsat data been the standard?
  - Appropriate spectral bands for land use applications
  - 30-meter resolution
  - 16-day temporal resolution
  - Cost and availability



# Let's reflect for a moment...



# Reflection-Absorption Signatures





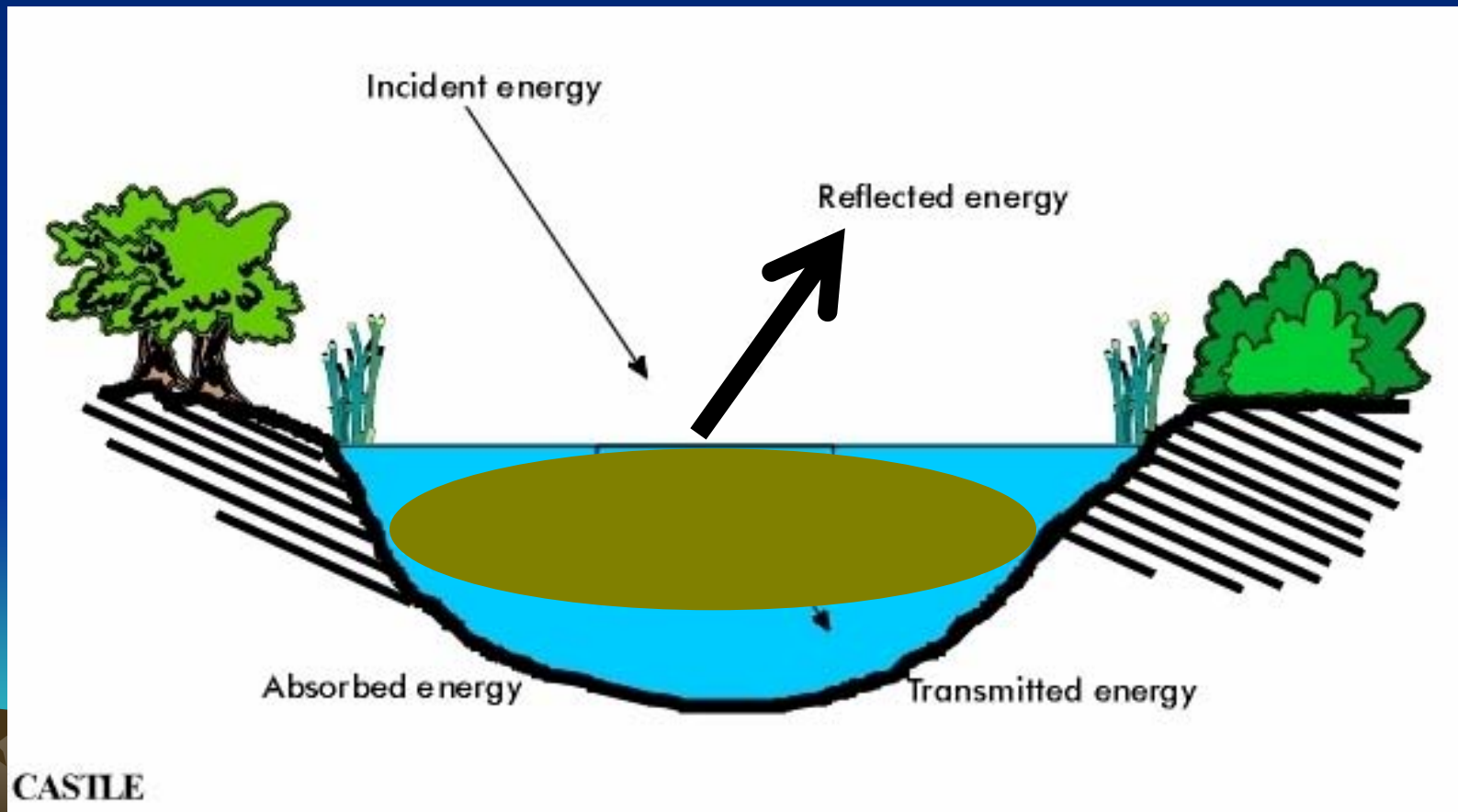
Water quality studies have traditionally used Landsat bands 1 (blue), 2 (green), and 4 (near IR)

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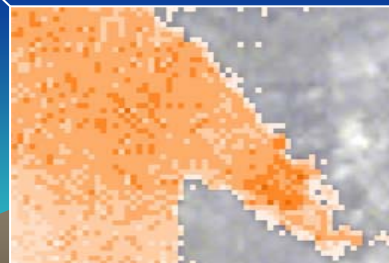
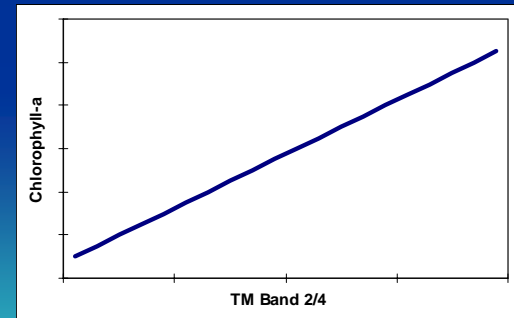
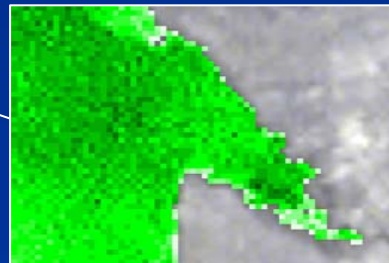
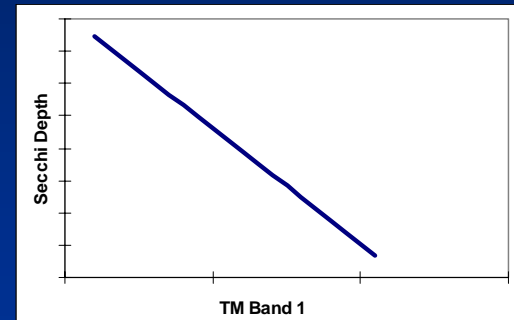
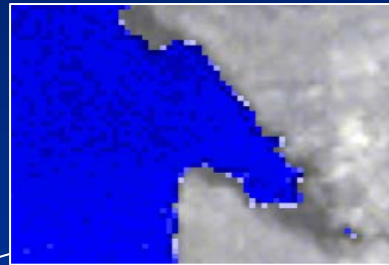
- **Band 1** (Turbidity): Is absorbed by clear water and reflected by suspended solid in water
- **Band 2** (Photosynthesis): Is reflected by plant matter and somewhat by soil particles
- **Band 4** (Photosynthesis): Is highly reflected by plant matter and less so by soil



# Transmission, Absorption, and Reflection



# Graphic Relationships



## Processed Grids

Band 1

Band 2

Band 4

Model

## Output Grids

Secchi

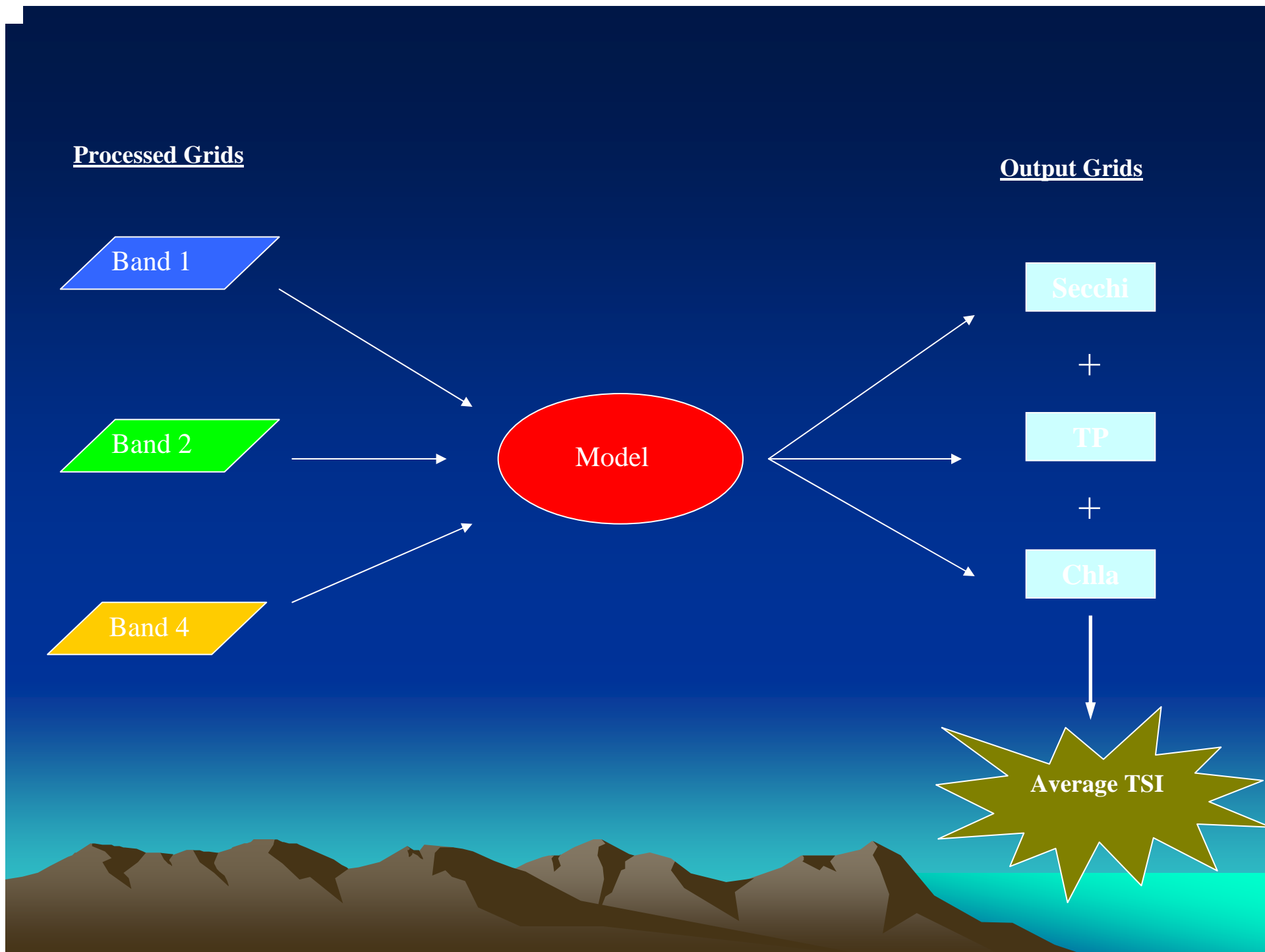
+

TP

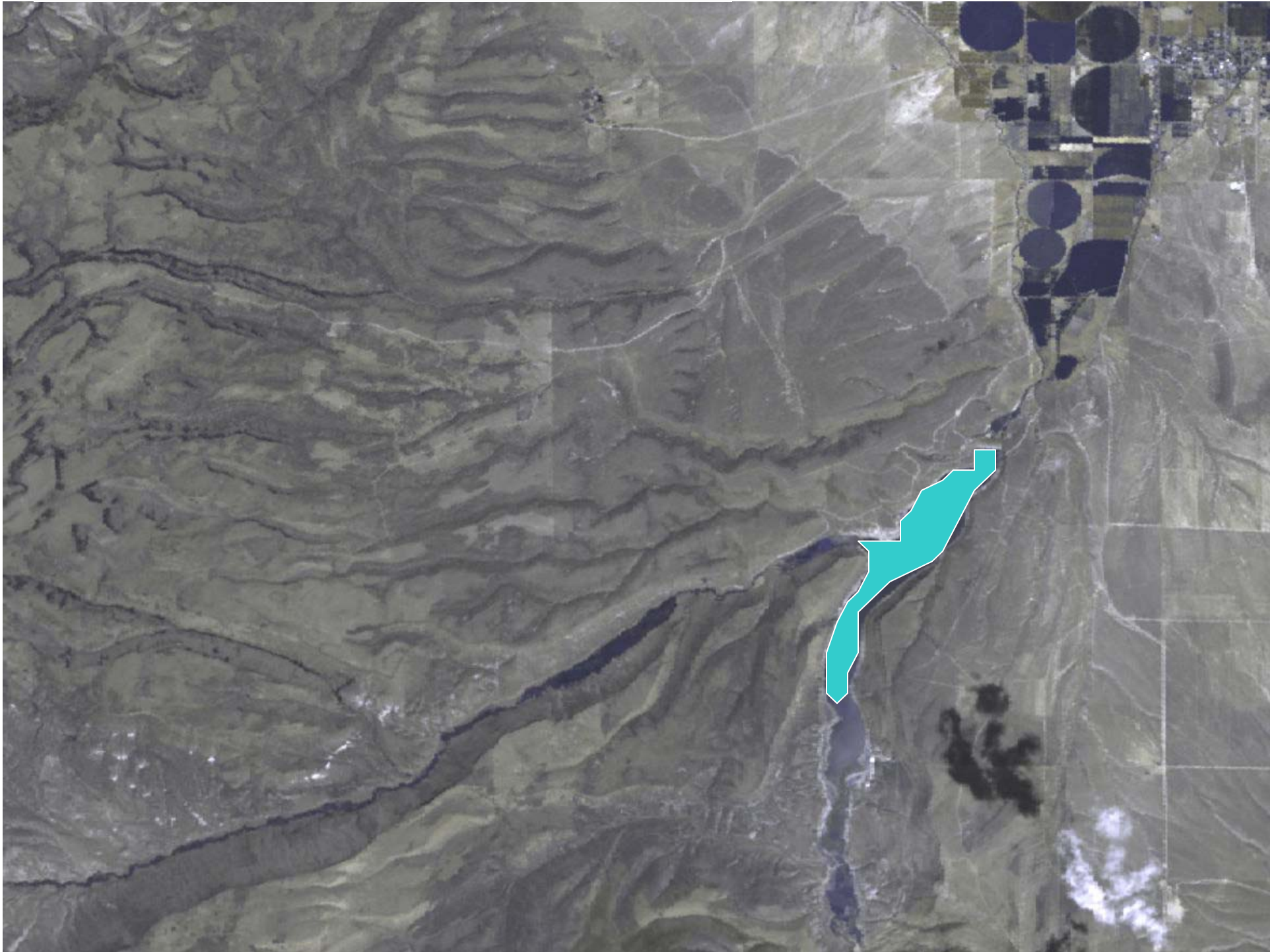
+

Chla

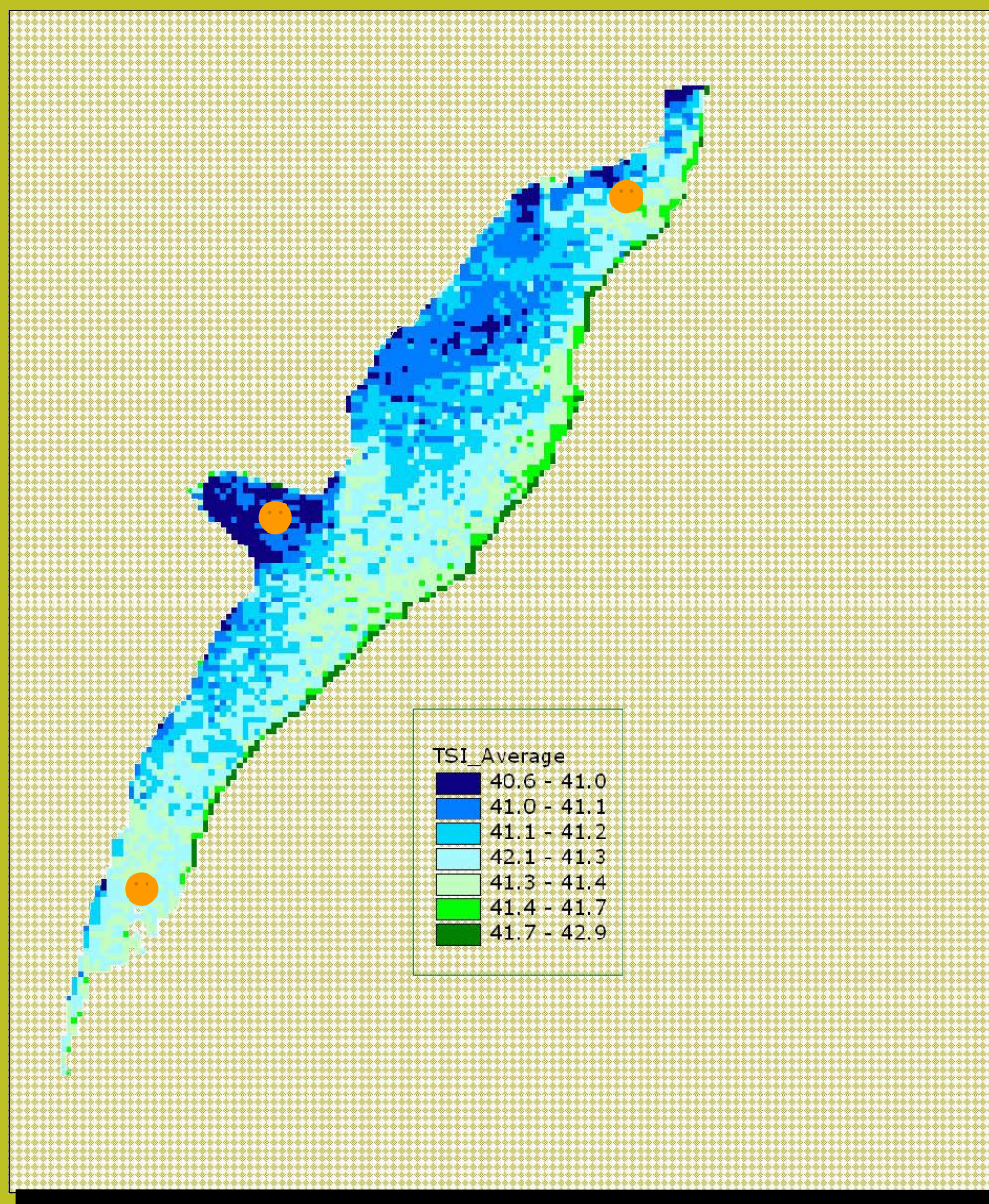
Average TSI











# RS Water Quality Assessment

## The Process

- Acquire *good* data for time period in question
- Import satellite data into GIS
- Adjust grid values of all bands (time of year, sensor calibration, etc)
- Develop relationships between field and satellite values to create a working descriptive model
- Run and evaluate model for southern Idaho
- Apply the model as a first cut



# Limitations of Proposed Remote Sensing Model

- Not all constituents are measured (temperature, DO)
- Not a silver bullet - field measurements still required
- Areas must be cloud free at time of acquisition
- Seasonal applicability may be limited
- 4-6 opportunities per month

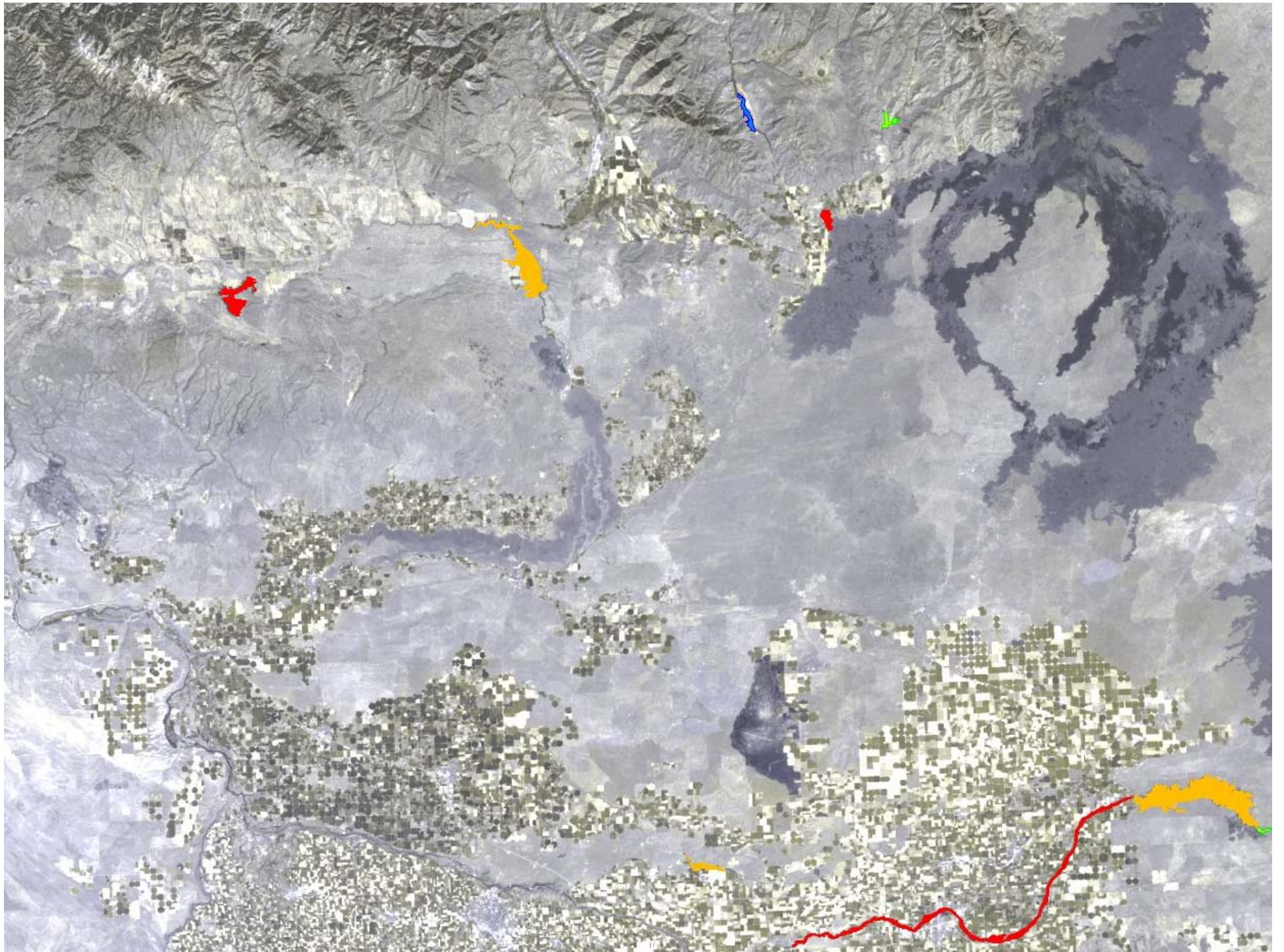




# Advantages of Proposed Remote Sensing Program

- Quick visualization of problem areas (1st cut)
- Continuous and dependable data
- Large historic dataset available for trend analysis
- Robust statistics (intra-lake variability)
- Cost effective (\$300 for multiple lakes)
- Statewide applicability and standardization







An aerial photograph of a river delta, likely the Nile, showing a complex network of distributaries branching out from a main river into a vast, arid landscape. The terrain is characterized by a mix of reddish-brown soil and patches of green vegetation. The word "Questions?" is superimposed in a large, white, serif font in the upper-middle portion of the image.

Questions?

# Carlson's TSI

The TSI values are calculated as follows:

- \* *Secchi disk* (SD) TSI (TSIS) =  $60 - 14.41 \ln(\text{SD})$ ;
  - \* *Total phosphorus* (TP) TSI (TSIP) =  $14.42 \ln \text{TP} + 4.15$ ;
  - \* *Chlorophyll-a* (chl-a) TSI (TSIC) =  $9.81 \ln \text{chl-a} + 30.6$ ;
- (chl-a and TP in micrograms per liter ( $\mu\text{g/L}$ ) and SD transparency in meters).

